1935

SOUTHAMPTON UNIVERSITY COLLEGE

MINISTRY OF HEALTH

CONSTRUCTION OF FLATS FOR THE WORKING CLASSES

INTERIM REPORT OF DEPARTMENTAL COMMITTEE

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32-312-1

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INTERIM REPORT OF DEPARTMENTAL COMMITTEE ON THE CONSTRUCTION OF FLATS FOR THE WORKING CLASSES

To the Right Hon. Sir E. HILTON YOUNG, G.B.E., D.S.O., D.S.C., M.P., Minister of Health.

SIR,

We were appointed by you on the 9th July, 1934, to be a Committee " to enquire into and report upon materials and methods of construction suitable for the building of flats for the working classes with special reference to efficiency and cost ". We now have the honour to submit an Interim Report.

INTRODUCTION

2. It was explained to us at our first meeting that our work would be of great importance in relation to the housing efforts of the Government, who envisaged the practical necessity of building flats for the replacement of slums and the relief of overcrowding in central areas. Reference was made to the view expressed by the Departmental Committee on Housing (para. 61 (2) of their Report, Cmd. 4397, 1933) that the present cost of flats was excessive and that there was urgent need for further examination of the technical and other problems involved; and to the opinion then hazarded that the solution would be found in new methods of planning or construction, or in the use of new materials, or in a combination of both. The significance was accordingly emphasised of research in building materials and of the utilisation of various methods of construction with a view to securing efficiency in the construction of flats at the lowest practicable costs.

We were invited to present an Interim Report including a review of the available methods if possible in readiness for the time when the 1935 Housing Bill was passed.

3. As a main Committee we have only met on three occasions. We found it more convenient to subdivide our work amongst a number of Sub-Committees to enable particular matters to be dealt with in more detail than would be possible in main Committee. Thus we have appointed a series of Sub-Committees as follows :—

(1) *Accommodation and planning* to deal with architectural aspects generally.

(2) *Habitability* to assist in the examination of schemes from the standpoint of occupancy by all types of the working classes.

(3) *Fire resistance* to consider the fire-resistance requirements in working class flats.

(4) *Acoustics* to evolve standards of acoustical requirements for working class flats.

(5) *Equipment* to consider equipment for heating, lighting, domestic hot water supply, lifts, etc.

(6) *Structural* to deal with matters of stability and strength of the structure.

(7) *Materials* to examine in detail requirements for external walling, wall surfacings, floor and roof coverings.

These Sub-Committees have held numerous meetings. Their constitution is given in Appendix I and we desire to express our appreciation of the services rendered by the co-opted members. Their findings to date are incorporated in the relevant sections of our Report.

4. You arranged that the technical services we required should in general be furnished by the Building Research Station of the Department of Scientific and Industrial Research. The valuable reports, test data and summaries of information supplied to us by the Station are referred to elsewhere.

5. For the purposes of our Interim Report we felt it to be unnecessary to invite oral evidence, except on the particular aspect of fire-resistance requirements (see para. 16). There was readily available to us, through the members of the Committee, Directors of Housing and other architects and organisations in the industry with whom contacts could soon be established, a wealth of information. We therefore decided as a practicable course in the first instance to compile data regarding typical blocks of flats erected in London, Liverpool, Glasgow, and other cities in Great Britain. The response to our requests for working drawings, specifications, quantities, design data and figures of actual cost was most gratifying. The schemes were then submitted to the Building Research Station for examination and report, and their findings reached after inspection of the buildings are embodied in our general review of existing materials and methods of construction (paras. 40-83). We also obtained from the Building Research Station copies of their reports on novel forms of construction adopted on the Continent and suggested for use in this country.

We decided to approach a few special organisations and invite them to submit memoranda. The use of steel-framed building construction is adequately described in the interesting and informative First Report (Slum Clearance and Re-Housing) issued by the Council for Research on Housing Construction, copies of which were kindly supplied to us by the Council. At our request, the Reinforced Concrete Association submitted a memorandum on the use of reinforced concrete in the construction of flats for the working classes. Groups of architects and individual architects and inventors who communicated with us were also asked to put their ideas in writing.

The Building Centre, who are proposing to publish a book on English and Continental Housing, have acceded to our request to furnish information. A brief note has already been received from them on new materials used abroad. Contacts have been established with several continental architects.

The Garden Cities and Town Planning Association and the Housing Centre have been good enough to supply statistics and references to literature. The Building Industries National Council have offered assistance and we have asked them to indicate any legal provisions affecting building which in their opinion or experience have been found unduly restrictive.

6. We have as a Committee visited a few blocks of flats in London. Several of our members, through their professional occupations, are familiar with the flats in other English cities and in Scotland. A number have inspected continental housing schemes, but we have not found it practicable or thought it essential at this stage to arrange for any special visits abroad.

7. At this point, we may perhaps briefly summarise the impressions derived from the fairly comprehensive information placed at our disposal on continental flats. The buildings in Berlin, Vienna, Rotterdam, etc., have received wide publicity and they are commonly cited as magnificent examples with which British tenements stand poor comparison. This view we feel to be exaggerated. They are more liberally provided with external amenities than in the average English scheme, though some of the amenities demand to be treated with great respect by the tenants, but their interior planning and accommodation are by no means superior to ours. In regard to actual methods of construction there are one or two interesting schemes abroad, but in general, the practice on the continent is to follow traditional brick construction. There are a few instances of framed buildings with brick or hollow block panel fillings. In certain respects only, such as for example, rendering over brickwork, lightweight aggregates for concrete, special types of partitions, and flat roof construction would detailed structural examination seem to be merited.

8. In order to make as precise a comparison as possible of the costs of different forms of construction, we have decided to secure estimates of the cost with these methods of providing the accommodation represented by a unit group of 5-storey flats. A skeleton design suitable for the application of all known forms of construction has been prepared by the Planning and Accommodation Sub-Committee, and a brief specification with instructions for tendering has been drawn up in consultation with other sub-Committees. (See also para. 38 and Appendix 2.)

Estimates for the cost of constructing the dwellings are being obtained from building contractors, specialist firms, and individual inventors; and we acknowledge our indebtedness to those who are assisting us in this way. The work involved is of some magnitude and as the figures will not be available for some time it would have delayed this Report too long to await their reception. Their examination must form one of the principal subjects of our main report.

MEASUREMENT OF EFFICIENCY

9. The efficiency of the various forms of construction for the building of working class flats should be interpreted in a wide sense. The flats must provide comfortable homes. Not only must the various materials used and the surfacing treatment adopted be fitted for their purposes, but regard must be paid to sociological aspects, or as we have termed it, habitability. We have in mind that the tenants may be wage-earners of varied types taken from over-crowded areas as well as from the slums.

Criteria

10. For assessing the merits and demerits of materials and forms of construction it is necessary to have criteria, preferably scientific and quantitative. Before the establishment of the Building Research Station, there was very little literature in England on the science of building, but in the past 15 years considerable scientific data have been accumulated. Sufficient information is, however, still not available to indicate precise criteria applicable to the behaviour of all materials in all circumstances. Indeed, only a few quantitative measures could be cited; for the rest, it is a question of judgment based on general scientific principles and experience.

A table of criteria, set down in the present state of knowledge, covering foundations, damp-proof courses, external walling, roofs, floor, partitions, and internal linings, would exhibit in the main a number of factors which are probably well known to most architects and others engaged in building. Nevertheless, it can be of great service if the underlying scientific principles, as indicated by the Building Research Station, are more precisely stated.

11. As an example, let us take floors and flooring. This subject can be most conveniently dealt with by separating the functions under two headings (A) Wearing surface or floor finish, and (B) supporting structure, and considering the properties required, the means for determining them, the standards to which these properties should conform and the means available for ensuring maintenance of standards.

12. The properties required of (A) floor finishes, are (1) resistance to abrasion under the particular conditions of wear to which they are subjected, (2) non-hardness, in the sense of comfort for the occupants, (3) warmth, again in the sense of comfort to the occupants, (4) quietness to the tread, (5) non-slipperiness, (6) constancy of volume, (7) durability, (8) continuity, in the sense of being jointless, (9) chemical composition compatible with sub-floor materials, (10) sound absorption, coupled with reduction of sound transmission. The floors should also be easy to clean and suffer no harmful effect from repeated wetting. For (1) there are tests; by drag abrasion, sand-blast abrasion and with the "Rattler" machine; as yet, no standards have been laid down (other than a British Standard Specification for concrete paving slabs), but it would not be impossible to define limits for test results. As regards (2), it is not certain what particular physical properties are important in hardness; concrete is said to be hard; wood is not. Floors must be not so soft that the furniture sinks into them. The assessment of hardness becomes important with floorings on the border-line, e.g. various jointless floor finishes. The modulus of elasticity in compression may be some guide. Many of the properties in relation to (3), warmth, remain to be decided. It has been suggested that a scale of coldness might be given by the

expression √ thermal conductivity × heat capacity. By a "quiet" floor (4) is presumably meant a floor where impact energy is dissipated in a compliant material, but no actual measurements have been considered. For non-slipperiness (5), it would probably be sufficient to measure co-efficients of friction between the floor and shoe leather, but a floor may become slippery in service, and the liability to this is more difficult to estimate. Changes in volume (6) mainly arise in practice through variations of moisture content; a common trouble is the shrinkage cracking of plastic finishes applied *in situ*. Limiting values for moisture movements can be prescribed (subject to an allowance still to be ascertained for the effects of constraint and creep). For example, instead of merely ordering "well-seasoned" timber, the seasoning can be defined in terms of a specific moisture content. Tests for durability (7) are very important in the case of new materials, but they are not easy to prescribe. The effects of age-ing require particular investigation. Standards for timber are imposed by inspection clauses in ordinary specifications. Cement concrete and granolithic finishes are regarded as durable if of a specific composition and proportioning. Continuity (8) in the flooring is a function of form and constancy of volume; it is important in so far as it controls harbourage of dirt and vermin; no measure for it has yet been attempted. For chemical composition (9) tentative limits can be laid down, which might define the quantities of constituents likely to lead to corrosion of structural members; this is important, for example, when magnesium oxychloride mixes are used. The co-efficient of sound absorption (10) of a flooring finish can be determined by test, but is probably only of minor importance.

13. The properties to be fulfilled by (B), the supporting floor structure, are (1) strength (2) fire resistance (3) resistance to sound transmission (4) durability.

Strength (1) can be determined by calculation based on experiment, and the standards prescribed are those imposed by theory and calculation, and to some extent by local building laws and rules of practice. In general, there is a sound basis of design and work can be controlled by specification and inspection. Fire resistance (2) is an important question which is dealt with more fully in the next subsection to this Report (paras. 15-20); here it suffices to say that although test methods have been laid down, there are as yet no facilities for the necessary full scale tests; moreover the standards required need to be established in terms of such tests. Sound transmission (3) is likewise a major subject which is discussed at length in another subsection (paras. 21-26). In brief, tests are needed on large scale structures of both air-borne noises and impact noises before standards can be defined. Durability (4) so far as the floor structure is concerned implies principally the protection of structural steel or reinforcing steel against corrosion. Methods of test comprise investigation of possible access of air and moisture to the steel, and the determination of any corrosive tendencies in materials coming into contact with the steel (e.g. coal residues as concrete aggregates). Local building laws and rules of practice as to the cover and encasement of steel as a protection against fire may be claimed to be a safeguard, *inter alia*, against corrosion, but do not necessarily afford any definite degree of protection. Maintenance of standards is ensured by specification of materials and workmanship, and inspection on the job.

In relation to the floor structure, the screedings and fillings offer a number of problems. There are tests available for soundness, volume changed with changes of moisture content, chemical and physical compatibility with other materials, but no standards are laid down and there are no means as yet of ensuring that any standard would be met. Economy in weight may be an important consideration, and there is scope for further investigation of lightweight concretes.

14. We have given floors and their finishes as an example. Similar analyses for the other elements of structure with which we are concerned would be necessary for a comprehensive survey but to quote them fully here would extend this Report unduly.

Fire Resistance

15. Protection against fire contributes a significant amount to the costs of building. Such protection is usually rightly demanded in building laws, by specifying certain types of construction in particular parts of the building. A special difficulty arises, however, in the case of new materials and constructional forms. Although the building laws are usually framed in such a way as to make it possible, in theory, for new materials and constructional forms to be used, it is difficult, in practice, to secure universal admission of any material or process not specifically mentioned, or (at any rate) already known to particular local authorities. This leads to uncertainty, as materials may be admitted by one authority and not admitted by another. At present there are no effective means of satisfying local authorities in general as to the admissibility of materials and forms of construction not previously recognized.

There would appear to be scope for economy in the adaptation of traditional constructional forms and the use of new ones if the fire risks in tenement buildings can be more definitely evaluated and grading rules and methods of test established acceptable to all local authorities.

16. Our Fire Resistance Sub-Committee have deemed it desirable to obtain some evidence of the occurrence and character of conflagrations in tenement buildings during the past few years. Such evidence has therefore been invited informally from the Fire Brigade Officers at London and Liverpool from the retired Firemaster of Edinburgh, and from the Fire Offices' Committee. Some evidence obtained by means of a questionnaire addressed to the Fire Brigade Officers at Brighton, Birmingham, Edinburgh, Liverpool and Manchester has also been supplied in a note submitted to the Sub-Committee by one of their co-opted members, Lieut.-Colonel Guy Symonds, D.S.O., Fire Advisor to the Home Office. From the evidence and from general experience, it seems clear that fires in buildings of the class in question are not likely to be very fierce, since the rooms do not contain much inflammable material, nor will the spread be very rapid; in most cases fire is confined to the room of origin. It must be remembered however that all the fires in evidence occurred in areas readily accessible to and protected by a fire brigade with at least sufficient permanent whole-time firemen to man the first turn-out appliance. Conditions might be less satisfactory in an area less efficiently protected. The real risk is that of loss of life through people in a

panic jumping from windows, particularly in upper storeys to which smoke has ascended.

17. The general problem of fire resistant construction has been elucidated in recent years by the issue of British Standard Definitions for Fire Resistance, Incombustibility and non-Inflammability of Building Materials and Structures, including methods of tests (B.S.S. 476—1932). Under this specification, the ability of a structure to withstand fire is defined in terms of the time during which it will perform its functions when subjected to the action of fire of a given intensity. Thus structures and the component parts of structures are classified into Grades A, B, C, D and E according to whether they will function satisfactorily in a fire for six hours, four hours, two hours, one hour and half an hour respectively. Unfortunately there is as yet no laboratory in England equipped to carry out tests on the full scale to the requirements of the specification. It is hoped, however, that the laboratory now being erected by the Fire Offices' Committee will shortly be ready, so that the Building Research Station will be able to conduct tests there and issue reports. There is need in the first instance for the scientific grading of traditional forms of construction to enable existing building laws to be adjusted in this respect; the next task is the grading of new forms. The London County Council Advisory Committee on the Amendment of the London Building Act, 1930, have already submitted a Report (printed in the Minutes of Proceedings of the Council of 27th February, 1934), recommending gradings for buildings based on the principles of the British Standard Specification; these recommendations are perforce conservative pending the accumulation of test data. We wish strongly to emphasise the desirability of arrangements being made for the conduct as rapidly as possible of the necessary fire tests by the Building Research Station.

18. In the meantime, the Building Research Station has furnished a note, at our request, on the data available from various sources, chiefly the United States of America. These data comprise the results of tests on floors, columns, walls and partitions.

19. In our deliberations on this subject we are mainly concerned with safety of life, for which protection may be afforded in five ways (1) by reducing exposure hazards by proper site planning and taking special precautions in the proximity of premises used for particular industrial or commercial purposes (c.f. Home Office Manual of Safety Requirements in Theatres and other places of Public Entertainment,* p. 20), (2) by limiting the possibility of rapid spread of fire and by restricting the spread of smoke, (3) by providing means of escape in case of fire, (4) by equipping the buildings with first-aid fire fighting appliances and (5) by so arranging the building as to secure free access by the Fire

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* H.M. Stationery Office, 1935.

Brigade. The form of construction allowable will be affected by the different means adopted.

20. We are disposed to the view that in blocks of flats of not more than 5 storeys in height, in central areas protected by a permanent fire brigade and out of proximity of buildings constituting a high hazard, the fire risk is almost negligible. As a general rule, it will be safe to rely on the prompt arrival of the brigade. Contingencies can however be envisaged, e.g. exceptional weather, which might lead to delay, so that some margin of fire resistance ought to be allowed for. Our conclusion therefore, is that, for blocks of flats provided with adequate means of escape and readily accessible to the fire brigades, it will suffice if structural elements normally conform to Grade D of the British Standard Specification, i.e., they offer one hour's resistance to fire. This conclusion is particularised in the recommendations we make in our review of existing forms of construction (paras. 40-83).

Acoustics

21. The problem of noise is of serious importance. Even in luxury flats and hotels the noise from neighbouring wireless sets, gramophones, pianos, added to noise from lifts, running water, and other equipment is occasionally barely tolerable. The need for insulation against sound is becoming increasingly felt. Troubles have become more and more intense as structural forms have departed from the older and heavier (and probably now more expensive) types. The little that is known about sound transmission leads to the idea that mass and discontinuity are deciding factors; most homogeneous partition materials have a reduction co-efficient determined by their weight—they follow the " mass law ". If types of structures are developed which are even lighter and more rigid than at present, due, say, to adjustment of legal provisions for fire resistant construction, then careful consideration will have to be given to the limits to which such " refinements " can be taken and still provide an inhabitable building; or, alternatively, there must be evolved some form of acoustic construction which will keep pace with the refinement in structure. We feel that all practicable steps must be taken to insulate flat dwellings against noise.

22. The acoustic difficulties in flat dwellings can be considered under two general headings :—

(1) Transmission of sound from one flat to the next by way of the floors, dividing walls and doors;

(2) Choice and installation of equipment in order that noises may be reduced so far as possible at the source.

It is assumed that occupants of a flat can find their own remedy against the noise they themselves make, but that noise made by their neighbours is likely to be a source of objection.

23. Existing information on sound transmission is admittedly meagre and much of the data that exist are not strictly comparable, since they have been obtained by different laboratories under different experimental conditions. An account of the existing information is given in Building Research Bulletin No. 14, The Reduction of Noise in Buildings, and in a number of text books and trade journals. We have regarded it as an important part of our work to ascertain the extent to which this information is adequate for application to the special problems under review, and to make recommendations for the lines along which further investigation should be directed immediately.

24. On the special question of sound transmission through floors, which is a vital one, we have taken advantage of the fact that the urgency of the problem had been foreseen by the Building Research Station, and they had utilised an existing structure to provide a laboratory for full-scale sound transmission tests on floor systems. A test floor was already in position. At our request, the Department of Scientific and Industrial Research have arranged for the tests in progress to be carried out by the National Physical Laboratory in advance of the normal time-table. The programme includes tests on the bare floor and under different conditions of covering, resistance being measured both to various impact sounds and air-borne noises.

25. With the concurrence of the Architectural Acoustics Committee of the Department of Scientific and Industrial Research, a programme of tests has also been drawn up on various types of partitions. Some results on small size and large size specimens tested at the National Physical Laboratory have already been received. While it is too early yet to make any definite statemente, it may be mentioned that the investigations point to the conclusion that it may be possible to combine economy in weight with good sound insulation by forms of discontinuous construction. The practical details by which the principle of discontinuity may be achieved are being worked out.

We are inclined to the opinion that the sound reduction capacity of a dividing wall between flats should be at least equal to that of a brick wall 8½ inches thick, solidly built and plastered on both sides. This might well be adopted as a standard.

26. We hope that the general investigations in acoustical problems that are being conducted by the Department of Scientific and Industrial Research will be pursued as energetically as possible so as to establish the basic principles involved in sound transmission through composite structures and adequate systems of test measurements. An assessment is required of the parts played by the structure, floors and walls, as well as a range of data regarding the different units of construction.

Structural factors

27. Consideration of structural factors is simplified by accumulated experience in regard to brick construction and the recent issues of up to date codes of practice* dealing with the use of structural steel and reinforced concrete in building. Special problems may, however, arise in respect of the revised and new forms of construction for which we hope to receive estimates of cost (see paras. 8, 38). Some experimental testing may be necessary, but we anticipate that measurement of efficiency will be practicable by means of ordinary principles of structural design.

Habitability

28. One over-riding consideration is the general habitability of the dwelling. No scientific criteria can be laid down and we are being guided by the views of the members of the Habitability Sub-Committee and others with considerable experience of the class of property under review and its tenants.

29. A particularly serious question arises in respect of infestation by bugs. No building can be made absolutely bug proof, and although efforts in this direction might soon pass the bounds of economic practicability, it would be worth while making some investigations of structural aspects to ascertain these practical limits. It is clear that the aim must be to eliminate harbourage in the building structure, and this means the avoidance of cracks, particularly those which occur at the junction of timber with other materials. There are two obvious lines of attack. First, to take elementary precautions in the selection of materials and by care in workmanship to prevent as far as possible the formation of cracks; and second, to deal in an appropriate manner with the junction of timber and plaster wherever they are used. Certain traditional wooden elements can be eliminated without loss of efficiency and others should be treated in a simple manner so that their junction with other materials can be sealed, e.g., by linen strips. From the more general aspects, the best procedure is to disinfest the tenant and his furniture where necessary before entry into a new flat, on the lines recommended in the Report of your Committee on the Eradication of Bed Bugs,† and to maintain strict supervision.

30. We consider that, as a general rule, wall and floor surfaces should be such as can easily be cleaned with soap and water. In kitchens, sculleries and bathrooms the surfaces should be capable of resisting the effects of steam and condensation.

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* (a) L.C.C. draft codes for the use of structural steel and reinforced concrete, etc., in building.

(b) B.S.S. 449 for the use of structural steel in building.

† Reports on Public Health and Medical Subjects No. 72; published for the Ministry of Health by H.M. Stationery Office, 1934.

ASSESSMENT OF COST

31. The question of comparative costs of different forms of construction is of great complexity. Even if an average relation could be established, it could hardly be regarded as universally applicable, since in any particular case conditions may be governed by character of the site, supply of materials, availability of skilled labour, etc. Moreover, a building is a composite structure and it is only within limits that particular forms of construction are comparable. It is nevertheless important to state the guiding principles as this subject forms a major part of our reference.

32. Comparisons of the actual cost of finished buildings are affected by variations in quality and price of materials with differing times and places, by divergencies in labour rates and workmanship, the utilisation or otherwise of special equipment and appliances, and the employment or otherwise of specialist firms. General organisation and speed of construction also have an important influence.

33. As an illustration of the problem of securing reasonably comparable figures of costs, we may take the case of concrete. Although the price of cement may not vary greatly the costs of aggregates are governed by the nearness of suitable deposits. The skill of the local artisans in the use of the materials is also a factor, and there is a differentiation between areas according to whether they are or are not served by the various specialist firms. When the quantity of concreting is large enough to permit the fullest use of the mixers, pumps and other mechanical equipment, there is an appreciable saving in the unit cost of the concrete. The cost of shuttering is a very variable item, and some firms have their own systems of shuttering which may exercise a controlling influence on price. Then there is the possibility of using cork or fibre boards to line the faces of concrete walls and employing them partly as shuttering. A further point which arises on the exsmination of figures of actual schemes is that the tender may have been a specially low one, owing possibly to work which could conveniently be performed in conjunction with other work in hand at the same time, or else to a special effort to secure the contract and keep men employed who would otherwise be idle.

34. As a basis of comparison of the costs of buildings the price per cubic foot is frequently adopted. Unless great care is taken to ensure that the items to be compared are in every way similar, this measure may be misleading. For example, a building with efficient thin walls and floors would work out at a relatively higher figure per cubic foot for the same accommodation as another with thicker walls and floors although the total cost may be less. Since the effective rentable accommodation is the area within the tenant's complete use, we consider that the fairest figure of comparison is the cost per superficial foot of the net floor areas. The cost per habitable room (reckoning living rooms and bedrooms, but not the

kitchens and bathrooms which are regarded as normal appurtenances) is also a useful figure where dimensions are more or less standard and the average number of rooms per dwelling is about the same.

35. In illustration of the difficulty of drawing conclusions from these different units of assessment, it may be stated that, for six representative schemes examined, the costs (in each case exclusive of clearing sites, foundations to the underside of ground floors and other work dependent upon the nature of the site, layout etc., architects' and other professional and supervision charges) are approximately as follows :—

at per cubic foot ...	6½d.	8¾d.	1/-	1/1	1/1	1/1½
at per square foot floor area.	8/3	9/3	11/6½	12/1	12/8½	15/1¾
at per habitable room.	£103	£76	£110 10	£93 10	£94	£142
The average number of rooms per flat are.	3	2·7	3·55	3·9	3·45	2·8

It should be noted that the cubic foot cost rates have been obtained by measuring the cubic contents of the buildings concerned in general accordance with the " R.I.B.A. Cubing Rules " except that the heights have been calculated from 6″ below ground floor levels instead of from the top of the foundation concrete. The floor area rates have been obtained by measuring the net areas of the floors of the flats (within walls and partitions), including private individual balconies, but excluding chimney breasts and the floor areas of common staircases and access galleries.

36. A closer analysis than the rate per cubic foot or square foot or per room is necessary for our purposes. It should comprise :-

(1) Foundations to damp-proof course;
(2) Structural walling, i.e. load carrying;
(3) Floors;
(4) Partitions, i.e. non weight carrying;
(5) Floor finishes;
(6) Plastering or its equivalent;
(7) Roofs, flat or pitched;
(8) Plumbing including hot water-supply;
(9) Heating;
(10) Drainage;
(11) Joinery work, windows and doors;
(12) Stairs;
(13) Painting.

37. As stated earlier, we arranged for the examination by the Building Research Station of the costs of typical blocks of flats, details of which had been supplied to us. A summary of the findings is embodied in our review of existing methods, (paras. 40-83).

38. We indicated in our introduction (para. 8) the scheme we have adopted for securing as close comparisons as possible of the cost of different forms of construction. A copy of the plan of the unit block of flats designed for cost comparative purposes is reproduced in Appendix 2, together with a copy of the instructions issued to building contractors and specialist firms etc., who have been good enough to agree to submit tenders. The design is intended to be readily adapted to all forms of construction; in particular, care has been taken to see that there is no handicap to framed construction or other new types of construction for which special claims have been made. We must emphasise that the design has only been evolved for the purpose of securing comparative costs, eliminating planning variables; it is not suggested as a standard design for regular adoption in building practice.

In the scheme, we are allowing estimators to submit any proposals they consider reasonable, irrespective of building laws. We shall attempt to assess the efficiency value of the units proposed and if we have occasion to do so will recommend modification of local building law, if it is found to be, in our opinion, unduly exacting.

39. The acid test is of course that of experience. What is desirable therefore is that the sponsors of such new forms of construction as are declared promising should have an opportunity of tendering for actual blocks of flats, if necessary as a frank experiment. This experiment could then be watched very carefully throughout the course of building operations, and definite conclusions thereafter drawn as to the advantages of the system in question.

REVIEW OF MATERIALS AND FORMS OF CONSTRUCTION

40. We have received from the Building Research Station a careful analytical review of materials and forms of construction used in the building of some typical working class flats actually constructed. This review incorporates up to date information based on scientific investigation and experience. Much of it would apply to all types of buildings—houses, offices, luxury flats and hotels. It forms indeed a skeleton text book on building science, and is hardly suitable for inclusion in this Report. We feel, however, that there is a real need for a text book of this kind. We have in mind for our future work the examination of selected structural elements and we hope that thereafter, if not before, the Station will be in a position to expand the various sections and publish, as rapidly as possible, a series of pamphlets dealing with different materials and elements of construction. The series would be a most valuable contribution to the development of progressive efficiency in the building industry.

41. We give below a brief review of existing materials and forms of construction. Much of this may be familiar to the majority of architects and building experts, but we trust it will be of some

general service in indicating the principal directions in which further economy and efficiency may be sought. Also, with this review before them of the subjects we have under consideration, architects and others will possibly be in a position to submit useful suggestions to us on points on which more information is shown to be needed.

General Forms of Construction

42. The principal forms of construction with which we are concerned are brick, steel frame and reinforced concrete. Many buildings may, of course, be composite.

43. By the brick building is usually implied one in which the load bearing walls are wholly of brick. A facing brick may be used as the exterior, or common brick may be covered with rendering or stucco. The walls may be cavity or solid. Some economy seems to be effected in building flats in brick by having a central spine wall to carry the floors.

Conventional brick construction has established itself very firmly. The possibilities it offers are familiar, and every advantage has been taken of practicable refinements in technique. It is easily adaptable to requirements and has so far withstood the challenge from new alternative forms of construction.

As a variant of brick construction there is possibility of advantage in using hollow clay blocks or compound units of perforated bricks of a type now becoming increasingly popular in Germany.

44. In steel frame construction, the loads are carried to the foundations by a framework of vertical steel columns and horizontal beams. The practice under normal building laws is to encase the steel with concrete or other approved material as a protection against fire and corrosion. This casing is expensive. The panels of the framework are filled in with brick (solid or cavity walling), reinforced concrete, hollow block, precast blocks, stone etc. ; lined steel sheeting also has its claims.

There is scope for economy in steel framed building by planning the structure in uniform bays (as recommended by the Council for Research on Housing Construction)—though there is some loss in adaptability; by such reduction of the encasement as may be justifiable or by taking the concrete into account in the strength of the members; and by the development of appropriate lightweight panel filling walls, e.g., by using lightweight concretes, precast slabs, hollow or perforated blocks, built-up brick panels, or special sheet units. There is also the possibility of using high tensile structural steel instead of mild steel for the framework.

Two French systems of steel framed construction merit special notice. In one, large pre-cast reinforced concrete blocks of ingenious design are made to fit together, and on to the framework, so providing an external leaf which is claimed to be self-supporting, thereby permitting lighter steel members; the wall is hollow, the inner leaf consisting of lightweight concrete or other partition blocks. In the other system, the external walling leaf is made by gunning concrete on to metal lathing placed round a light steel framework. They are both less fire resisting than normal English construction, owing to the omission of some of the steel encasement.

45. Reinforced concrete construction may be similar to steel frame, the columns and beams of reinforced concrete replacing the steel members; or alternatively the external walls and the cross walls of the building may comprise the load-bearing elements. In an intermediate form adopted in a recent scheme, the cross walls are integral with the floors and carry all the loads, the external walls being merely panel fillings; this offers a promising line of development.

There is scope for economy in reinforced concrete construction by making the wall complete with external and internal finishes in one operation.

46. We are hopeful that our scheme for obtaining comparative estimates of costs of construction will give an opportunity of examining all forms that offer reasonable promise. We are anxious to encourage the sponsors of new systems to come forward and submit their proposals in this definite form. Obviously, new types of construction may be expensive at the outset, until experience is gained in their use, and we must take this into consideration. We realise also that careful consideration may have to be given to the character and conditions of service of the manipulative labour such systems may involve.

47. A special difficulty may arise in connection with the use of new systems. Parts of them may be patented, and the assemblage may be outside the scope of ordinary contractors and need the services of the inventors. There may be a question of working the system under licence and paying royalties. Furthermore, the inventors may be engineers without whose guidance ths system can scarcely be operated. This difficulty will have to be borne in mind in considering the application of new forms of construction.

48. Economy in building may, it has been urged, be advanced by further standardisation. The British Standards Institution has done excellent work in promoting standard specifications for materials, etc., and standard dimensions for different units, such as pipes and joinery These specifications are not however always used to the full extent. Standards are also being evolved by the trades concerned for fittings such as baths and sanitary ware. The question has been raised by the Council for Research on Housing Construction as to whether standardisation on a wider scale is practicable. Presumably they have in mind assembly items such as complete plumbing and sanitary systems. While there is scope for further standardisation in kitchen and bathroom equipment and miscellaneous fittings, we are not yet convinced

that much can be done on more general lines applicable throughout the country.

49. There are advocates also of what is termed " dry technique ", by which is meant the manufacture of all units in the factory, so that assemblage only is necessary on the site. It is usually related to steel frame building. There are no examples of flats so built in this country and very few that can be adduced from abroad, so that the matter is, at present, rather academic. We will weigh the possible advantages and disadvantages very carefully as and when specific illustrations come to our notice.

50. We have heard that manufacturers complain that they are unable to secure the acceptance of new materials by local authorities even though the materials may have been most favourably reported upon by the Building Research Station after exhaustive tests. With considerable trouble they may succeed in persuading one authority, but another will refuse; and as there are many to be approached the obstacles to progress are alleged to be really serious. We feel that it would be of considerable benefit if some system could be devised whereby a material reported upon favourably by the Building Research Station was notified to local authorities as one which could be regarded as a suitable alternative to materials of conventional sanction. It would be useful also to include in the notice a statement as to the successful use of the material in any locality where it had been approved by the authority.

51. We have observed in our examination of the costs of building flats that low prices have been attained in large organisations with strong costing sections and a considerable fund of experience at their disposal; by complete detailing and specification, so that there is no element of uncertainty for which builders tendering have to make provisions in their estimate; by consistent economy in material and labour throughout the building; and by strengthening the general contractor's control of the work, leaving him to select his sub-contractors. It is of advantage also if as little as possible of the work in the contract is covered by " provisional sums ".

Good organisation in the architect's offices and on the part of the contractors (which includes what is known in America as working to " time and progress " schedules) leads to considerable economy.

52. We will now proceed to consider building elements in more detail, confining our attention for the time being to blocks of flats not more than five storeys in height.

External Walling

53. Typical forms of external walls are brick, reinforced concrete, and brick or other panels in steel or reinforced concrete frames.

54. *Brick*—The brick walls are usually solid, consisting of facing brick on the outside backed by common brick, or wholly of common brick rendered. Cavity brickwork may be used for upper storeys.

In one scheme examined, the walls, approximately 50 feet in height, are 1½ brick thick for the four lower floors, diminishing to 1 brick on the fifth; as the mortar used is one which should develop excellent hydraulic strength and should undergo little deterioration over very long periods of time, the strength of the walls is no doubt more than adequate. The lower parts of the walls are not of the thickness prescribed by urban series of model byelaws or by the London Building Act, where no differentiation is made between hydraulic and non-hydraulic mortars, but we feel that the variation should be permissible when satisfactory hydraulic mortars are employed. The advantages obtained by very strong cement mortars is open to debate and hardly justifies the extra price asked.

Although it is often assumed that solid walls of one brick or one brick and a half adequately exclude damp, nevertheless they occasionally fail in exposed situations. Renderings and stuccos in Great Britain are often bad, whereas in Germany and Switzerland they are reported to be generally good. The problem of making brickwork damp-proof is difficult and we are giving special attention to it in our Sub-Committee on Materials. Cavity walls, properly constructed, are at present the best solution.

55. *Reinforced Concrete*—In one scheme examined, where some of the external reinforced concrete walls are load bearing members independent of any separate frame, although integral with the floor, they are 7 inches thick, faced on the outside with a proprietary stucco finish, and lined inside with fibre board applied to the concrete with adhesive. In another, where the reinforced concrete walls are panels of a reinforced concrete frame, they are 4 inches thick, faced externally with a proprietary finish of the stone paint type, and lined with 1-inch thickness of cork slab placed in the shuttering before the walls are poured.

It is noted that a single coat plastering on these concrete wall linings gives a finish equivalent in appearance to two-coat work on brick walls.

If cork or fibre board or plaster block is used to line the faces of concrete walls, there seems no reason why it should not be used partly as shuttering, thus saving some of the cost of shuttering and the cost of using an adhesive. Further experience in this use is required, however, before it can be assumed to be generally successful.

The exterior finish to concrete walls presents considerable difficulties. The problem is similar to renderings on brickwork. Architectural effect and resistance to rain penetration are achieved by relatively expensive facing treatments requiring regular renewal. Trials are being made with thin slabs of weather proof material that can be used as external shuttering and left as external finish.

The cost of steel reinforcement in concrete walls necessary to prevent cracking forms so small a part of the whole that designs might well be more liberal in this respect than is sometimes the case.

56. *Steel or Reinforced Concrete Framework*—In a framed building there is a possibility of annoyance due to structure-borne noise unless precautions are taken at the earliest stages of design to introduce proper insulation and damping. The attention of designers should be particularly directed to this point.

For Grade D (1 hour) fire-resistance, we consider that pending full scale tests, it will be sufficient in steel framed building if the external columns are built into the wall construction and the internal projections covered with plaster or equivalent material where not already covered by partition or division walls; similarly, internal columns need not be protected by concrete casing. The plaster or other covering should, however, be spaced away from the steel (e.g. on metal lath) and special care should be taken to see that it is of good quality; it would also be desirable to protect the plaster at the base of the columns, e.g., by carrying the concrete of a concrete floor up to a height of 6 inches up the wall. Main beams where they occur over partitions or dividing walls, would not require concrete encasement on the soffits and may likewise be covered with plaster on metal lath, etc.

Normal forms of reinforced concrete members are fire resistant, although some differences in performance may be expected with different aggregates. For example, a silicious gravel or sandstone would entail a thicker cover to the reinforcement than, say, blast-furnace slag. The properties in an aggregate which lead to a high degree of fire resistance are stated to be, low heat conductivity, high specific heat and capacity to retain moisture in the pore structure. In general these properties are possessed by the artificial aggregates to a greater extent than by the natural ones. For Grade D requirements, no distinction need however be drawn between the various aggregates.

Panel Walls

57. Reinforced concrete panel walls have already been considered above in relation to reinforced concrete framework (see para. 55). Other types of panel walls are brick (solid or cavity), hollow blocks of clay or concrete.

The development of suitable light panel fillings, which are not required to take load since they are supported by the framework, but should be capable of resisting the weather, keeping out damp, and affording good heat insulation, will be a determining factor in the economical use of framed construction.

Damp Proof Courses

58. Good slates in cement undoubtedly provide a safe damp-proof course, and we will take them as a standard in considering the efficiency of other materials suggested for use in this vital part of the structure.

Internal Walls

59. *Brick*—Brick party walls between buildings are usually at least 8½ inches thick. For this reason, the 8½-inch brick wall has come to be regarded as a standard for stability as well as for fire resistance and sound insulation. The sound insulation of such a wall, if plastered, even if reduced to 4½ inches at chimney openings, is such that ordinary conversation is diminished to the verge of inaudibility. For Grade D fire-resistance it is ample: indeed it is probable that 4½ inches of clay, sand-lime or concrete brick unplastered would satisfy Grade D requirements (see para. 17).

60. *Reinforced Concrete*—The main cross walls in one block of flats examined are 7 inches thick reinforced concrete, faced on one side with fibre board. Sound insulation is excellent, but the superiority over 8½-inch brickwork in this respect is largely attributable to the fact that the dividing walls between flats are not reduced in thickness behind chimney openings. Fire resistance is ample; indeed three inches of unplastered reinforced concrete, with suitable aggregate, would probably satisfy Grade D requirements. The only defect might be shrinkage cracks, if the concrete is not properly reinforced.

61. *Hollow Clay Blocks*—In one block of flats examined with reinforced concrete floors and a reinforced concrete frame, the dividing walls consist of 4-inch hollow clay blocks, plastered with lime-sand undercoat and finished with neat lime. The walls are amply strong and stable. The sound reduction is not normally so good as that of an 8½-inch brick wall, but here acoustic requirements are assisted by virtue of the walls being supported on relatively massive beams forming part of the structural frame and not on thin floor slabs. The fire resistance will no doubt conform to Grade D. The wall will be practically immune from cracking due to moisture movement.

62. *Hollow Concrete Blocks*—Hollow blocks can be made of concrete which are equal in strength and durability to hollow clay blocks; care must, however, be taken by proper maturing to reduce the risk of shrinkage cracking to a minimum. The fire resistance will depend on the selection of the aggregate, but with suitable aggregate, 4-inch blocks, plastered both sides would, it is expected, conform to Grade D requirements. The acoustical properties will be little better than those of clay blocks.

63. *Clinker Concrete Slabs*—If made in conformity with British Standard Specification No. 492, solid clinker concrete slabs can be accepted as satisfactory. For Grade D fire resistance, the slabs should, it is thought, be at least 4 inches thick, plastered both sides. A single thickness (3 inch) of a clinker concrete slab partition does not afford good sound insulation, and the insulation may be further reduced in the course of time by shrinkage cracks. A double thickness of 2-inch slabs, with (say) a 2-inch cavity, would be much better, and it may be possible to obtain insulation very

much superior to that of an 8½-inch brick wall when the problem of avoiding edge transmission has been solved.

64. *Other Types*—Some interesting new types, e.g., gypsum blocks, are already on the market. There is scope for the development of special partitions to meet the requirements of fire-resistance and acoustics.

Floors

65. As indicated earlier (para. 24), the floors in buildings present a very difficult acoustic problem. Various tests are in hand by the National Physical Laboratory on the transmission of impact noises as well as of air-borne sounds. Where flats are separated by a partition erected on the floor structure, impact noises are freely transmitted laterally by way of the floor system. There seem to be two directions in which mitigation of the nuisance may be sought (1) impact noises may be reduced by special treatment of the wearing surface and by break of continuity in the floor system at the dividing walls and (2) by the use of suspended ceilings.

66. For fire-resistance requirements one hour's resistance (Grade D construction) is regarded as adequate under the conditions stated previously (para. 20), except where shops are installed in a lower storey; here the separating floor should conform to Grade B requirements (four hours' resistance), and the shop construction to Grade C (two hours' resistance). Practically all types of floors normally used will satisfy Grade D requirements, with the possible exception of the timber floor filled in between the joists with "deafening" which is discussed more fully below.

67. There are many different types of floor in use, and no attempt can be made here at a comprehensive review. A few are taken as typical examples only.

Suspended Floors

Typical forms of suspended floors are filler joist, reinforced concrete slabs, reinforced concrete (ribs and thin slabs), reinforced concrete (hollow tiles and ribs), precast reinforced concrete beams and timber. Claims are also made for ribbed steel floors.

Filler Joist—The filler joist floor provides a cheap type of concrete suspended floor. It has been widely used for a large number of years and is generally durable, though some shrinkage cracking is unavoidable. Sometimes the top flanges of the steel are not covered with the usual inch of concrete : this may or may not be a justifiable economy depending on whether protection against corrosion can be secured more cheaply otherwise

Reinforced Concrete Slabs—Changes in volume are a cause of trouble in concrete structural members and care should be taken to avoid shrinkage cracks by adequate reinforcement etc.

Reinforced Concrete Ribs and Slab—Shrinkage movements may be restrained by a system of reinforcement in two directions. An independent ceiling masks the cracking if it occurs, but cracks may appear in a floor covering bonded to the slabs.

Reinforced Concrete and Hollow Tile—This form of construction allows of a certain economy in weight in comparison with solid slabs, and provides a continuous soffit for the direct application of ceiling finishes.

Timber—In an important traditional form, timber floors consist of 8 inch x 2 inch joists at 18 inch centres covered with 1 inch "tongued and grooved" boarding. Half inch board is secured between the joists on 1 inch x 1 inch fillets, and on this is laid a layer of 3 inches of ashes and ½ inch of lime plaster ("deafening"). This economical type of floor is invariably used in flat construction in Scotland.

In the ordinary course, premature deterioration of a timber floor need only be feared in the event of a failure of some other part of the structure whereby moisture obtains access to the timber, so leading to dry rot fungus attack. Major troubles due to change of volume of the timber with moisture can be avoided by the use of suitably seasoned material.

The actual degree of fire resistance must depend to a large extent on the protection afforded to the joists by the plaster used for the ceilings. Gypsum plaster, for example, offers a fair resistance to the action of fire, but the joists might easily become ignited in a fire of any serious intensity and duration. The extent to which the ash filling renders the floor system "slow burning" is conjectural. It is thought probable that the degree of fire resistance may possibly not be sufficient for Grade D requirements; tests are needed to determine this.

If there is a direct, rigid contact between the wearing surface and the ceiling it is not to be expected that a floor structure of this kind will offer any appreciable resistance to impact noises. A sheet of felt is sometimes introduced between the flooring and the joists to mitigate this defect. Even with the ash and plaster filling, the floors are lighter than solid concrete floors and the resistance to air-borne noise correspondingly less.

Ground Floors

Four main types or ground floors may conveniently be discussed, viz. boarded floors on solid concrete on the ground, boarded floors on joists and sleeper walls, linoleum secured to concrete direct on the ground, and coloured asphalt mastic on solid concrete. Of these, the first is probably the cheapest.

Boarded floors on solid concrete.—The surface of the concrete is usually treated with a brushed coating of tar and pitch; the boarding, creosoted on the underside, is nailed through to the clinker concrete covering the ground concrete while the pitch is still warm. On anything but a dry sub-soil the brushed coating is not likely to be effective in preventing damp from penetrating to the boarding, and the use of a continuous bituminous membrane is essential if dry rot is to be avoided. The efficiency of the membrane calls for specification of the quality and quantity of bitumen.

Boarded floors on joists supported on sleeper walls.—This is conventional cottage construction of the best type and, with the reservation that the sub-floor ventilation must be thorough, it needs no special comment.

Solid concrete floors, covered with linoleum secured direct to cement mortar screeding—There may be difficulty in obtaining satisfactory adhesion of thick linoleum finishes to a concrete base in contact with moist earth, and unless the damp is prevented from penetrating to the linoleum the durability of the linoleum is open to question.

Coloured asphalt mastic on solid concrete.—If this form of floor could be laid economically, it would be a very satisfactory type. It is jointless and should be easily washable. It should however be sufficiently hard to resist indentation from furniture.

Floor Coverings

68. Coverings to ground floors have already been discussed incidentally above. It will be convenient to consider separately floor coverings for the lobby, kitchen and scullery, living room, bedroom and bathroom. The factors to be taken into account are first cost, maintenance, durability, and habitability (including deadening of impact noises). In general, the floor coverings should be such as can be cleaned with soap and water and can resist hard wear.

If cost is a dominant factor then cement rendering is the best for the lobby; otherwise quarry tiles, with granolithic or cement and sand margin to avoid cutting, would be preferable, or possibly coloured asphalt.

For the kitchen or scullery, quarry tiles are no doubt the best, if cost permits; to prevent undue coldness or hardness to the feet, duck boards or linoleum strips in front of the sink would be of advantage. Other types of flooring used are boarding, granolithic rendering, cement and sand rendering, linoleum on cement screed, etc.

Wood boarding (plain or "tongued and grooved"), linoleum on cement screed, and coloured asphalt are typical flooring for the living room, bedroom and bathroom. Boarding, possibly nailed direct to breeze infilling, would be selected on grounds of cost; the wood should, of course, be suitably seasoned and close finished; otherwise with wear and shrinkage it affords lodgment for dirt and harbourage for vermin. Linoleum secured to concrete should wear well with careful tenants.

Some objection might be raised against wood flooring owing to the possibility of affording harbourage for the bed bug, but complaints about bugs in floors are rare, except in cases of severe infestation.

Ceiling Finishes

69. Finishes for walls and ceilings are of great importance; they contribute a much larger amount than is normally realised to the cost of building, and they provide a range of difficult problems.

Mention of ceiling finishes has already been made above in reference to structural floors of particular types. Ordinary finishes are lime and gypsum plaster on wood or metal lathing, fibre board with skimming coat of plaster, plaster board with skimming coat, Keene's cement plain faced direct on concrete; all distempered. A typical suspended ceiling is of fibrous plaster slabs with skimming coat.

The question of plaster for ceilings has been discussed in notes and reports issued by the Building Research Station and the subject is too large to be treated in this Report. Standard specifications for lime and gypsum for general building uses are now in course of final preparation by the British Standards Institution and the guidance thereby to be afforded will meet a long felt want. Plaster board seems to possess several obvious advantages and fibre boards, though liable to shrinkage cracks, are used with some success.

A painted ceiling in the scullery is desirable.

Wall Finishes

70. Again, the usual finishes are lime or gypsum plaster. Sometimes fibre board or plaster board or plywood is used. An interesting lining used on the continent consists of pigmented aluminous cement, a polished face being obtained by casting on burnished wrought iron. A polished lining can also be obtained by using resins on steel or asbestos cement.

For the lobby and sanitary offices, cement rendering is sometimes employed or sand-lime bricks flush-pointed.

To distemper the kitchen and scullery walls is regarded by many as a waste of money; a good paint is, in their opinion, necessary. Whilst inclining to the use of paint, we feel that immediate decoration should be avoided; indeed, decoration should, if possible, be postponed for a year, although a single coat of non-washable distemper might be used to " brighten " the building up for immediate occupation.

Whilst in some recently erected buildings the plastering generally is very poor and extensive cracking has occurred, satisfactory results can be obtained with two coat plaster work in the lobby, living room and bedroom. Papering in the bedroom is not to be encouraged: plaster, distempered or preferably painted, is considered desirable. Wall boards are open to objection from the standpoint of vermin harbourage in cracks and joints.

Tiling in the kitchen or scullery may well repay the cost; it need not be very expensive where much of the wall space is taken up with cupboards, etc.

Skirtings

71. The essential requirements in skirtings is to avoid cracks and gaps which would provide harbourage for vermin.

On a boarded floor a satisfactory skirting is sometimes obtained with flush cement 4 inches high with small wooden quadrant mould secured to the floor. For cement and sand floors a coved cement and sand skirting is suitable. Tiles and granolithic to match the floors are also appropriate. Wood skirtings are not so satisfactory. The possibilities of steel skirtings merit exploration.

Picture rails

72. In view of the harbourage that may be afforded to the bed bug, picture rails may well be omitted, and picture hooks supplied instead. If a picture rail is provided, lengths of gas barrel on clips built direct into the wall are preferable, apart from appearance, to wood.

Curtain Rods

73. It is desirable to make special provision for curtain rods for windows.

Doors

74. For the external door it is important to provide an effective water bar and clearance for a mat.

Doors leading from a flat to a common landing passage or stairway should have a fire resistance of 1 hour (Grade D) and they should preferably be self-closing. If these doors are closed it would be some little time before smoke and hot gases would produce alarming conditions in passages and on stairways in the building. An unpanelled deal door not less than 2 inches thick would probably meet Grade D requirements; oak, teak, or soft wood impregnated with ammonium phosphate would certainly comply. When glazing is needed, it should be of wired glass, but until more exhaustive tests are carried out nothing definite can be said about the use of small panes with metal framing.

A British Standard Specification has recently been issued for wooden doors and affords sufficient guidance in regard to them. Hitherto there have been curious variations in the dimensions adopted. Stock pattern doors which are normally used when they fit the architect's design are much cheaper than doors made in the workshop and are apparently equally satisfactory. A steel frame and architrave combined may offer decided advantages. For wooden frames, small "flat section" architraves are sometimes used and linen strips have been found to be a satisfactory method of sealing the joint between the timber frame and the plaster surrounds.

Windows

75. Spread of fire by way of windows seems almost unknown in tenement buildings in the United Kingdom, though in New York it appears fairly common. It would seem unnecessary to advise any special fire resistant frames or glazing.

There is some evidence that the maintenance costs of wooden windows are lower than those of the early cheaper forms of steel casements. Owing to the larger glass area, however, the steel casement transmits a larger amount of light than the wooden window, and this factor may be important where projecting balconies are installed (see para. 85). Steel windows are easier to clean and the manufacturers are paying special attention to designs for flats. A standard specification for wooden window casements and frames and double hung sashes and cased frames will, it is understood, be issued shortly by the British Standards Institution.

For internal sills use is ordinarily made of painted wood, thin tile or heavy quarry tile; the latter is much the most expensive. Efficient external sills are necessary.

Cupboards

76. It may be advisable to have cupboards which are removable, so as to facilitate the cleaning of the walls and the disinfestation of the rooms.

Sanitary Fittings

77. The size and depth of the sink require selection, having regard to the fact that the sink may be used for washing clothes. The combination sink and wash-tub, used in Scotland, is a good hygienic arrangement.

The " Sitz " bath is only second best, except in the case of flats for old persons, and a full sized bath is preferred. The installation of economical shower baths may well merit exploration.

Hardware

78. There appears to be scope for good simple standard patterns for ironmongery fittings.

Roofs

79. It is convenient to discuss pitched roofs and flat roofs separately.

Pitched Roofs—The conventional type of roof is the pitched roof, the supporting structure consisting of timber rafters, purlins, etc., and the covering of slates, clay or concrete tiles often on boarding, with or without felting. There are considerable disparities in the sizes of scantlings employed so that there seems room for economy in the design of the timber framing, particularly if light coverings are used. For example, the use of interlocking clay tiles affords a saving in weight, and with the very best types, properly laid, both the boarding and the felting can perhaps be omitted.

From the fire hazard standpoint, it is desirable to avoid a common roof space over different flats in one block, since it may enable a fairly rapid spread of fire. A fire of this sort does not, however, threaten the means of escape, and a reasonable measure of fire resistance in the ceilings below the roof may be sufficient: an extra precaution would be to run some of the dividing walls up to the underside of the roof covering.

Flat Roofs—Typical forms of flat roofs are reinforced concrete slabs, or reinforced concrete and hollow tile, covered with asphalt mastic or bituminous built-up felt roofing bitumen coated and heavily gritted. Claims are also made for slates, rubber impregnated concrete, asbestos cement and metal sheeting, as a covering. The eaves may overhang or there may be a parapet. Sometimes a suspended ceiling is incorporated. The bituminous felt roofing shows an appreciable saving in cost as compared with asphalt mastic, though it is unsuitable for roofs that are to have regular traffic over them. Parapet walls are expensive and might well be omitted when the design of a building permits and the site is not too much exposed.

Changes in volume may be troublesome in a roof slab under certain circumstances. The most serious changes are due to variations in temperature and moisture. The dark colour of some roofing materials results in rapid absorption of solar heat; this leads to heating of the structural roof system and consequent thermal expansion. The possibility of this movement should be taken into account in the design of the supporting structure; in steel or reinforced concrete framed buildings the effects of roof expansion are usually less serious than in buildings with load-bearing brick walls. Movements due to changes in moisture content may be restrained by proper reinforcement of the roof slabs. To promote adequate heat insulation, the most effective treatment is to have a light coloured outside roof surface, and so to reflect the solar radiation. By incorporating insulating material in the roof slabs, the flat roof may afford thermal insulation comparable with that of a pitched roof; an air space between the ceiling and the concrete slab gives added advantage.

Stairs and Staircases

80. In the majority of the blocks of flats examined precast concrete stairs have been used; they are faced with granolithic concrete and finished with carborundum; galvanised steel nosings may be incorporated. An alternative is to pour the steps *in situ* and sprinkle the upper surfaces of the treads with carborundum; this may be cheaper. Although no troubles from slippery steps have been reported even with solid granolithic steps, the incorporation of carborundum in the tread appears desirable.

The conventional balustrades are of wrought iron; occasionally there is a wrought iron handrail. Galvanised wrought iron tubing may be used for handrails and standards in the staircase balustrade.

Panels are filled in with interwoven wire mesh on stout wire frames.

There is considerable variety in the treatments used for lining the staircases; for example, blue brick is sometimes used for a dado, with sand lime brick above; or glazed tiles, coloured or painted cement may be used as dados, with facing bricks or either plastered or stone-painted linings above. An essential requirement is a hard washable dado of adequate height. A terrazzo or pebble-dash rendering, or concrete walls with exposed aggregate (as adopted frequently on the continent) might well be suitable. Moderately hard, rough-textured facing bricks also offer possibilities. There seems scope for economy in selecting a dado and lining, and the methods of finishing concrete walls need investigation.

Galleries

81. A common type of access to a block of flats is by means of a gallery. The tenants reach their flats from staircases opening to galleries serving a few flats each. The treatment accorded to the pavings and soffits to these galleries is an appreciable item of cost. The usual paving is concrete and granolithic finishes or asphalt on cement mortar screedings. Where there is no asphalt, some care may be necessary to ensure that shrinkage cracks in the structural concrete do not conduct moisture into the building. Where filler joist construction is adopted for the floors (see para. 67) asphalt is essential. Soffits may be of concrete left smooth coated with lime-cement slurry, or white cement rendering with front edges throated, or cement rendering finished with special coatings. The first of these treatments may be expected to have the advantage of cheapness and ease of renewal.

The galleries afford a convenient means of escape from fire, particularly if a solid parapet is provided on the outer side at least 3 ft. 6 inches high to protect from the effect of flame or hot gases coming from the windows below.

Balconies

82. There is a growing tendency to provide each flat with a private balcony. From the structural aspect, there is little comment to make. Where the private balcony of one flat abuts on another, an alternative means of fire escape may be provided by having a door in the partition; this would normally be locked, and the key kept in a mica-faced box.

Fireplaces, Flues and Ventilators

83. The installation of flues and chimneys for fires burning solid fuel represents an appreciable item in the cost of building.

The number of causes of fires coming under the Home Office heading of " Stoves, flues, hearths and grates " is very marked, but the cases in question refer mainly to buildings of brick and joisted construction of the older type. There is no doubt, however, that if the open hearth could be dispensed with there would be less risk of fire; in order to prevent fires caused by sparks or dropping coals, it would be well to include a brick or concrete kerb as part of the hearth construction.

In the provision of ventilators to flue-less rooms there is a variety of treatment. Investigations at the Building Research Station have shown under experimental conditions that a normal wall ventilator enables the air in an unheated flue-less room to be changed as frequently as that in a similar room with an unlighted open fire, but it is a matter of common observation that the wall ventilator can rarely be tolerated when a cold wind blows direct against the wall. In consequence, the wall ventilator is often filled up with rags, or paper is pasted over it. If, without it, there is insufficient ventilation in a flue-less room—and this is a matter for further investigation—some attention might with advantage be given to the problem of finding an efficient form of ventilator.

EQUIPMENT

84. Strictly speaking, we are only concerned within our terms of reference with equipment and associated amenities in so far as they affect the structure, but we may perhaps be permitted to state some general views.

Lighting

85. Electric lighting is usual, and it is desirable to have good standard wiring. Gas is also used for lighting and can now be controlled by switch.

Natural illumination should be considered under two heads, daylight and sunlight. The latter is somewhat easier to examine. The amount of sunshine entering a room depends principally on the orientation of the block, the obstruction due to neighbouring buildings and the obstruction of projections on the building itself. Galleries and projecting balconies must inevitably cut off some sunshine; this amount may be negligible in winter when the sun is low and in summer they may provide some necessary shade. Daylight factors are being investigated by various scientific workers; the subject is complicated because of the necessity for taking into account the light from the whole sky. Galleries and projecting balconies have a pronounced darkening effect.

Heating

86. It is usual to provide a fire in the form of stove, open fire, or range (burning coal, coke or smokeless fuel) in the living room, and a fireplace for coal or gas or a plug for an electric fire in at least one bedroom. For continuous heating gas or electric fires are very expensive, and the only practicable alternative to the open fire is communal heating. It is claimed that hot water radiators as well as a supply of hot water for domestic purposes can be supplied economically from a central plant and we are investigating this claim. If open fires could be dispensed with, there would be

considerable saving in flues and chimneys. On the other hand, the open fire is adjustable to different needs; it can be used for burning rubbish and can be auxiliary to a cooking oven and to a boiler for the supply of domestic hot water. It provides the focal point for the occupants of a room. As a compromise, it may be worth while having central heating and hot water supply whilst still having a fire in the living room if costs permit.

We are investigating the costs of various heating systems as applied to our unit five-storey block.

Cooking

87. A cooker combined with a living room fire is usually supplied, with an auxiliary gas or electric cooker in the kitchen or scullery.

Hot Water Supply

88. We are considering all existing methods and new proposals for hot water supply, bearing in mind the desirability of providing each dwelling with reasonably ample facilities.

Washing and Drying

89. Communal accommodation for washing and drying clothes is popular in some parts of the country but unpopular in others. Frequently, washing is done in the kitchen or bathroom, and the wall surfaces should then be capable of resisting effects of condensation (see para. 70). A private drying balcony is a feature of some continental flats and of one block shortly to be erected in London. Drying space is sometimes provided on open ground, on the flat roof, or under the pitched roof.

Plumbing

90. The claims advanced for the one-pipe system as against the normal system will be investigated in terms of our unit five-storey block.

Refuse Disposal

91. The disposal of refuse is a very troublesome problem. A common practice is to have a ventilated shoot to a ground floor container. Alternatively there are bins to each flat. It is not too easy to avoid smells and the scattering of garbage.

In an interesting French system, the rubbish is put down the sink and is carried by suction pump to a dryer and incinerator. The installation is only appropriate to a large scheme and is much more expensive than the shoot or bin system.

Lifts

92. As we are confining our attention for the present to blocks of flats not exceeding five storeys in height, we have not considered the question of lifts. For higher blocks, lifts will have to be considered.

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SUMMARY

We may summarise this interim report and our principal recommendations as follows :—

1. We emphasise that building materials and methods of construction suitable for the building of flats for the working classes must be considered with regard to efficiency and cost from a wide angle and taking into full account the desirability of securing adequate conditions of comfort for the occupants. We therefore attach great importance to the views, obtained through our Habitability Sub-Committee and in other ways, of those who have had experience in the maintenance and management of properties of the kind in question. (Paras. 3, 9, 28-30.)

2. Scientific criteria in quantitative terms cannot as yet be laid down for assessing the technical merits and demerits of the various constructional forms, but general scientific principles, applied in association with practical experience, can afford a good guide. The inclusion in this Report of a statement of the criteria relating to all structural elements would have extended the document unduly, and we have limited ourselves to one example, namely, floors. (Paras. 10-13.)

3. Whilst precautions against damage from fire are rightly prescribed by building laws, they contribute appreciably to the cost of building. Concerning ourselves with blocks of flats not more than five storeys in height and mainly with hazard to life, we feel, on the evidence we have obtained, that the risks that have to be faced are negligible in ordinary areas covered by permanently manned fire brigades. We therefore recommend that under these conditions and where adequate means of escape from fire are provided, the rules of practice should be adjusted so as to allow the use of structural elements which provide fire resistance of one hour's duration. (Grade D requirements of British Standard Specification No. 476.) It is desirable that elements so accepted should be proved by test on the full scale and we hope that the Building Research Station and the Department of Scientific and Industrial Research will shortly be in a position to carry out the necessary tests in the new laboratory of the Fire Offices' Committee. In the meantime, we have indicated in the relevant paragraphs of our report those elements which, in our opinion, based on examination of test data from other countries, would meet the requirements. An important particular case is that of the steel framed building where we express the view that the concrete or other encasement insisted upon in normal practice may be omitted if the steel members are built into the walls, floors, or partitions, or the exposed portions covered with carefully specified plaster or other approved coating spaced away from the steel. (Paras. 15-20, 56.)

4. Troubles due to transmission of sound from flat to flat may be a serious nuisance, and we feel that every effort must be made to combat noise. The problem is a very difficult one since little is as yet known of the way in which sound is conducted through a building and of the part played by the structure, floors and walls. Investigations are being undertaken by the Department of Scientific and Industrial Research, and we would urge the prosecution of this research with all speed. With the concurrence of the Architectural Acoustics Committee of the Research Department, certain tests on walls and floors are being carried out on our behalf in advance of their normal programme and will, we expect, give immediately useful results. On the information before us we are of the opinion that the sound reduction capacity of a dividing wall between flats should be equivalent at least to that of an 8½-inch brick wall plastered on both sides. The transmission of impact noises on floors may be minimised by suitable insulation of the wearing surface and by a break of continuity in the floor system between dwellings. (Paras. 21-26, 65, 67.)

5. We refer to the serious character of infestation of buildings by the bed bug and indicate some elementary precautions that should be taken to prevent cracks and cavities that would serve as harbourages. The best general procedure is where necessary to disinfest the tenants and their furniture before entry into a new dwelling and thereafter to maintain strict supervision. Paras. 29, 68, 70-72, 76.)

6. We point out the numerous difficulties that arise in attempting to estimate comparative costs of different materials and processes of construction and we indicate briefly the results of our review of existing typical buildings. To secure a more definite measure of cost we have adopted a scheme for obtaining costs of different forms of construction on a uniform basis in terms of a unit five-storey block. Estimators are allowed full freedom in advancing proposals and we seek to encourage those with new ideas to submit them for precise examination. (Paras. 8, 31-39.)

7. We have received from the Building Research Station a series of notes on the efficiency of different forms of construction used in typical blocks of flats in England and Scotland, together with special notes on interesting foreign systems. We have also had a memorandum from the Station dealing with costs. The main points brought out in the latter document are incorporated in this Report. The former constitutes almost a skeleton text book on building materials and we make extracts from it. We feel that a text book of this kind would be of great value and we strongly recommend to the consideration of the Building Research Station that they should expand the various sections as soon as may be practicable and issue them as a series of separate publications. (Para. 40.)

8. We review the general forms of construction and indicate the directions in which increased economy and efficiency seem in our view to be possible. In this connection we urge that in order to assist in the modern adaptation of conventional materials and processes and the introduction of new ones it would be desirable to make such administrative arrangements as will ensure that a material or process submitted for test to the Building Research Station and reported upon favourably is notified to local authorities and others concerned as one that may be regarded as coming into the category of suitable alternatives to those of conventional sanction. (Paras. 42-51.)

9. We deal in some detail with materials and systems used in external walling, internal walls, floors, floor coverings, ceiling and wall finishes, roofs, stairs and staircases, galleries, balconies, fireplaces, etc., and with miscellaneous items such as picture rails, curtain rods, doors, windows, cupboards, sanitary fittings, hardware. (Paras. 53-83.)

10. Although within our terms of reference we are strictly only concerned with equipment and associated amenities in so far as they affect the structure and the costs of building, we have ventured to submit some general views on these matters. (Paras. 84-92.)

We have the honour to be, Sir,

Your obedient Servants,

(Signed) G. W. HUMPHREYS (*Chairman*).
EWART S. ANDREWS.
HENRY V. ASHLEY.
OSCAR FABER.
G. TOPHAM FORREST.
IAN B. M. HAMILTON.
B. L. HURST.
L. H. KEAY.
FRANCIS LORNE.
J. A. MACINTYRE.
R. TRAVERS MORGAN.
STANLEY C. RAMSEY.
A. SCOTT.
W. L. SCOTT.
R. E. STRADLING.
JOHN WILSON.

(Signed) A. ZAIMAN (*Secretary*).

13th May, 1935.

APPENDIX 1

LIST OF MEMBERS OF SUB-COMMITTEES

SUB-COMMITTEE ON ACCOMMODATION AND PLANNING

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L. H. Keay, Esq., O.B.E., F.R.I.B.A.
Francis Lorne, Esq., F.R.I.B.A.
Stanley C. Ramsey, Esq., F.R.I.B.A.
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Dr. G. W. C. Kaye, O.B.E.
Stanley V. Ramsey, Esq., F.R.I.B.A.
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Francis Lorne, Esq., F.R.I.B.A.
T. Moodie, Esq. (for G. Topham Forrest, Esq., F.R.I.B.A., F.R.S.E.).
Walter W. Nobbs, Esq., M.I.Mech.E., M.I.H.V.E., M.Amer.Soc. H.V.E.
J. Roger Preston, Esq., M.I.Mech.E., M.R.S.I., M.I.H.V.E., F.I.Arb.

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Lt.-Col. Guy Symonds, D.S.O.

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Miss E. E. Perry, F.S.I.
Dr. W. G. Clark, M.B., Ch.B., D.P.H.
G. Topham Forrest, Esq., F.R.I.B.A., F.R.S.E. (or deputy).
Ian B. M. Hamilton, Esq., B.A., A.R.I.B.A.
Professor W. W. Jameson, M.D., F.R.C.P., Ch.B., D.P.H.
Miss M. M. Jeffrey, O.B.E.
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APPENDIX 2

SCHEME FOR SECURING COMPARATIVE COSTS OF THE CONSTRUCTION OF A UNIT BLOCK OF FLATS

Object

The object of the scheme is to obtain reliable figures of the comparative costs of different methods of construction suitable for use in tenement buildings. The standard plan (attached hereto) of the five storey block (60 flats) has been designed solely for the purpose of providing a reasonable common basis of comparison.

Scope of Estimate

The block is to be considered as one of a series of three, so as to allow for economies practicable on a scheme of this magnitude.

Each floor of the block is identical. The building must be so dimensioned internally as to give the accommodation indicated. Actually, in the drawing, allowance is made for 8½-inch dividing walls and 3-inch partitions, but these dimensions need not be strictly adhered to. Minor variations in dimensions (e.g., in the size of chimney breasts) that are desired to facilitate construction are permitted.

The estimate should not include for private balconies, drainage, heating, cooking and lighting services or sanitary equipment. Plumbing should also be excluded unless the estimator desires otherwise (see below).

It may be assumed that the site is level and that at 4 feet below the ground the safe bearing capacity of the soil is 2 tons per square foot. The ground floor should be 1 foot above ground level and the height of each storey should be 8 feet clear from floor to ceiling.

The roof may be flat or pitched or mansard on fifth floor.

External walls must be stable, fire-resistant, and of weather-resistance and heat-insulation equivalent to at least a 8½-inch solid brick wall rendered. Floors must be fire-resistant and provide reasonable resistance to transmission of noise. Dividing walls between flats should be stable, fire-resistant, and have a sound reduction corresponding to a 8½-inch brick wall plastered on both sides. Carpentry, joinery, wall, floor and ceiling finishes (and plumbing, if desired) are left to the choice of the individual estimators.

For the purpose of calculating the loads on slabs, beams, columns, piers, walls and foundations the minimum superimposed load on each floor and on the roof shall be estimated as equivalent to the dead loads specified in the recent London County Council draft codes of practice for the use of structural steel and reinforced concrete in buildings. The permissible stresses in steel and concrete shall also conform to those codes.

Otherwise, any desired departure from building regulations or byelaws is permitted.

It is to be assumed that the construction of the buildings (3 blocks) is to be completed in a period of not more than 70 weeks.

Information required

It is desired that estimators should submit detail drawings, specifications (wherein, in particular, any departures from building regulations and byelaws should be indicated), structural design data and detailed prices based on London rates for materials and labour.

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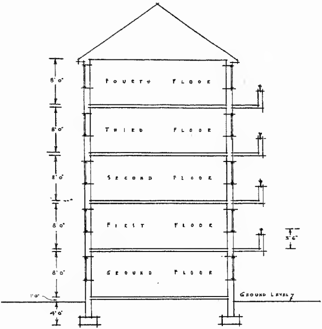
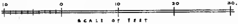
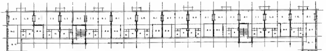


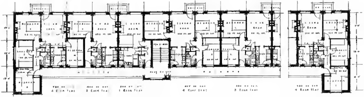
SECTION THROUGH FIVE
STOREY BLOCK OF FLATS
SHOWING FLOOR LEVELS ETC.



MINISTRY OF HEALTH
WHITEHALL. G.W.L.



TYPICAL FLOOR PLAN SHOWING TYPES & ARRANGEMENTS OF FLATS



SUGGESTED 5 STOREY BLOCK OF 60 FLATS